AUSTRALIAN JOURNAL OF ENGINEERING AND TECHNOLOGY RESEARCH (AJMFR)
Vol. 2, Issue 1 - 2017

COAL BED METHANE IN PAKISTAN: DIFFICULTIES AND PROSPECTS

Tahir Hussain Soomro
Department of Petroleum & N. Gas Engineering, Mehran UET Shaheed Z.A Bhutto Campus, Khairpur Mirs, Pakistan

Abdul Samad Shaikh
Department of Petroleum & N.Gas Engineering, Mehran UET Shaheed Z.A Bhutto Campus, Khairpur Mirs, Pakistan

Zeeshan Ali Lashari
Department of Petroleum & N.Gas Engineering, Mehran UET Shaheed Z.A Bhutto Campus, Khairpur Mirs, Pakistan

Note: This paper has been accepted for publication from the submissions made at the 2nd National Conference on *Intelligent Manufacturing & Sustainable Energy Systems (IMSES 2016) - Pakistan*

ABSTRACT:

The availability of energy resources is of prominent importance to society. The greatest challenge, the energy sector is facing today, is how to meet the rising demand of energy. On the other hand, the depletion of natural resources is also posing a concern. To meet the rapidly increasing demand for energy and faster depletion of conventional energy resources, Pakistan with other countries is desperately searching for alternate energy resources like coal bed methane (CBM), shale gas, and gas hydrate. CBM is considered to be the most viable resource of these and Pakistan is indeed blessed with vast yet untapped resources waiting to be explored. Pakistan with 185 billion tons is the 7th largest country of the world in terms of coal reserves and Pakistan makes 4.5% of the total world's coal reserves. The present paper discusses the prospects of CBM as a clean energy source, difficulty involved in production of CBM, and enhanced recovery techniques. In this regard, one Pakistani coal field is selected and coal contents are determined by analyzing the collected samples.

1. INTRODUCTION:

Depletion of conventional resources, and rising demand for clean energy challenges Pakistan to hunt for alternatives resources. Intense importance has been given for searching out more and more energy resources; significantly non-conventional ones like CBM, shale gas & gas hydrates, as gas is more favorable compared to oil or coal. CBM is considered to be one of the most viable alternatives to deal the situation. With increasing demand and rising oil and gas prices, CBM is definitely a feasible alternative energy source. Coal bed methane is generated during coalification process which gets adsorbed on coal at higher pressure. However, it is a mining hazard. Presence of CBM in underground mine not only makes mining works difficult and dangerous but also makes it very expensive and not economical.

However, CBM is a significantly clean fuel if utilized properly. CBM is a clean gas having heating value

of approximately 8500 KCal/kg compared to 9000 KCal/kg of natural gas. It is of pipeline quality; hence can be fed directly to national pipeline grid without enough treatment. Methane gas production from coalbed would lead to de-methanation of coal beds and avoidance of methane emissions into the environment, thus turning an atmospheric hazard into a clean energy resource. Pakistan in the field of coal as seventh largest in the world, Pakistan has good prospects for commercial production of coalbed methane. Methane may be a possible alternative to compressed natural gas (CNG) and its use as automotive fuel will certainly help reducing pollution levels.

India is one of the select countries which have undertaken steps through a transparent policy to harness domestic CBM resources. The Government of India has received overwhelming responses from prospective producers with several big players starting operations on exploration and development of CBM in India and set to become the fourth after US, Australia, and China in terms of exploration and production of coal bed methane.

However, in order to fully develop India's CBM potential, delineation of prospective CBM blocks is necessary. There are other measures like provision of technical training, promotion of research and development, and transfer of CBM development technologies that can further the growth of the sector.

India lacks in CBM related services which delayed the scheduled production. Efficient production of CBM is becoming a real challenge to the E & P companies due to lack in detailed reservoir characterization. So far, the most investigations have been limited to measurement of adsorption isotherms under static conditions and is deficient in providing information of gas pressure-driven and concentration-driven conditions. More care should be taken on measurement of porosity and permeability also. To produce more methane from the coal enhanced technology like CO2 sequestration may be implemented. This process can not only reduce the emission of this gas to atmosphere, will also help in extra production of methane gas [2]. Though, presently, CO2 is not an implemented much because of high cost. But the necessity to reduce greenhouse gas emissions has provided a dual role for coal beds - as a source of natural gas and as a repository for CO2.

S. No	Province	Coal Reserves
1	Sindh	184,623
2	Balochistan	217
3	Punjab	235
4	Khyber Pakhtun Khuwa	91 5
5	Azad Jamu kashmir	9
Total		185,175

Coal Reserves of Pakistan

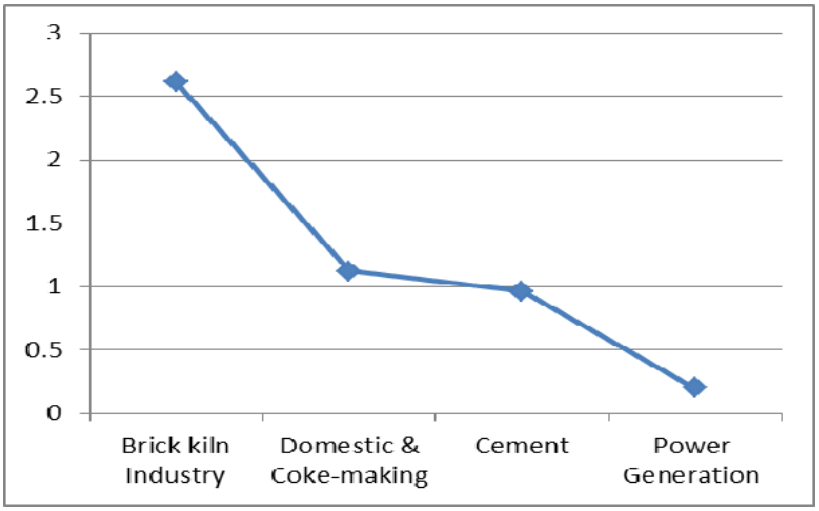
In the present investigation, Thar coal field has been selected as the study area. Samples have been collected from various locations & depths. Standard methods have been followed to characterize the collected coal samples and evaluation gas reserve.

2. GLOBAL AND PAKISTANI SCENARIO:

Global Scenario: The largest CBM resource bases lie in the former Soviet Union, Canada, China, Australia and the United States. However, much of the world's CBM recovery potential remains untapped. In 2006, it was estimated that of global resources totaling 143 trillion cubic meters, only 1 trillion cubic meters was actually recovered from reserves.

This is due to a lack of incentive in some countries to fully exploit the resource base, particularly in parts of the former Soviet Union where conventional natural gas is abundant. The United States has demonstrated a strong drive to utilize its resource base. Exploitation in Canada has been somewhat slower than in the US but is expected to increase with the development of new exploration and extraction technologies. The global CBM activities are shown in Fig. 1. The potential for supplementing significant proportions of natural gas supply with CBM is also growing in China, where demand for natural gas was set to outstrip domestic production by 2010.

Pakistani scenario: In Pakistan, coal deposits presence was known before of independence. Its economic value was highlighted in the late 80's when large reserves of coal were discovered in the Lakhra and Sonda area of Sindh. In 1992 deposits of 175.5 Billion tonnes was discovered in an area of 9000 sq. km in Tharparkar Desert [3, 4]. Coal reserves exits in Sindh, Baluchistan, Punjab, Khyber Paktun Khuwa (formerly known as NWPF) and Azad Jammu Kashmir, estimated about 185.5 billion tons of Lignite to sub-bituminous ranks details are shown in Table. The importance of coal as industrial fuel is well known in the industrialists, because of its low price and good heating value, but the high emission of the coal flame is a distinct advantage. Initially, coal was not used as fuel in the cement plants, now cement industry realized the importance of Coal as a fuel and started using the coal. It is used for direct firing in the manufacture of cement, bricks, pipes, glass tanks and metal smelting, and as boiler fuel for the supply of steam to process plant in the paper, chemical and food processing industries. In the brick kiln, it is estimated that one ton of coal have same energy potential as of one tonne oil. Pakistan coal consumption by industrial sector wise is given as under:

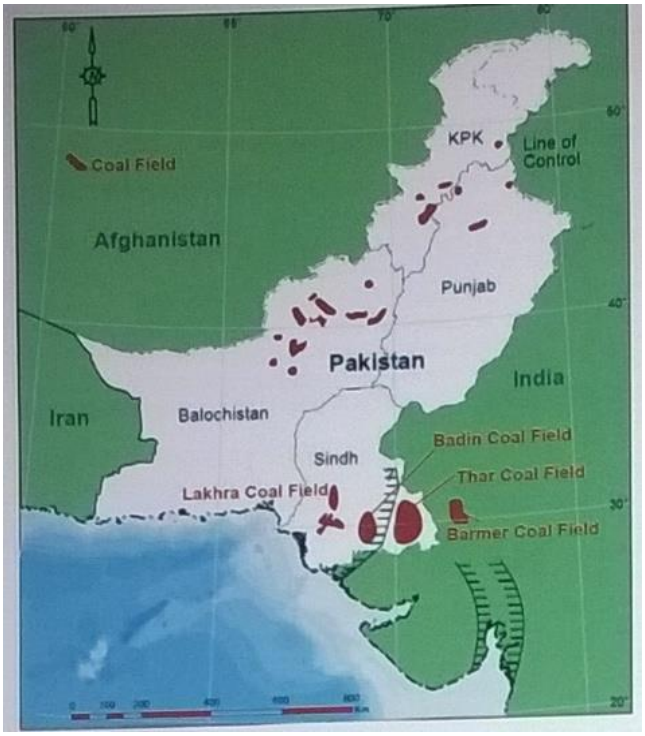


Coal Consumption by sector wise in Pakistan

MATERIALS AND METHOD

A. Sample collection and characterization

As coal is not exposed on the surface the core samples and borehole logs were collected by Geological survey of Pakistan from VV-14, SV-13, VV-12 boreholes at Block # 1, after detail core examination at Block # 1 is divided into Sinhar Vikian and varvai sub-blocks and borehole codes are given after the sub-blocks. The shallowest and deepest of coal samples are obtained at 143.8m (VV-12) and 245.28 (SV-13) depths. Efforts were made to sample all major verities within coal seams and more than one sample was taken from thick seams.



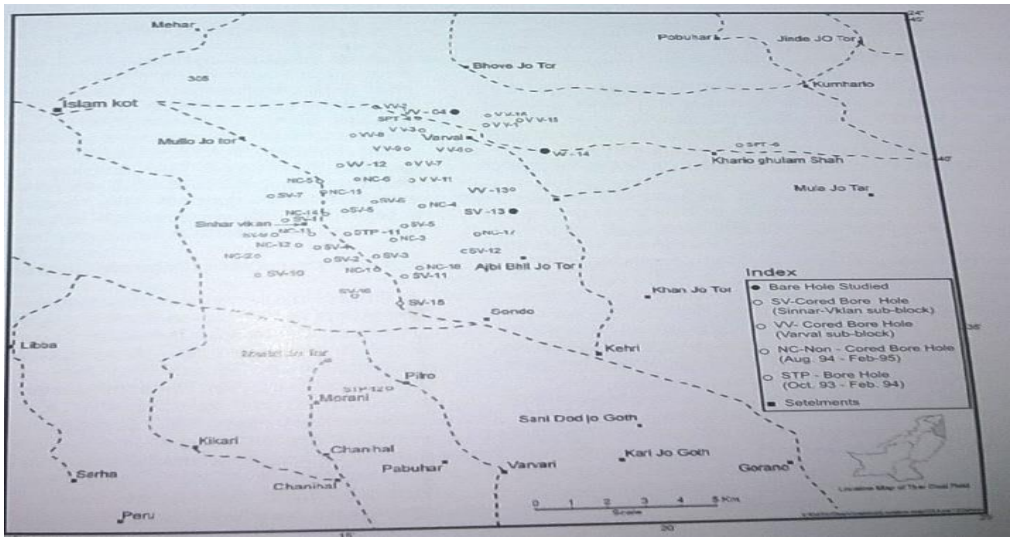
ANALYTICAL METHODS

The following analytical techniques were applied for the study

1. For organic petrography, polished blocks were prepared according to ISO 7404 (2004) procedure. Maceral analyses and vitrinite/huminite reflectance measurements (Rr %) were carried out using a Zeiss MPV3 microscopic equipped with a photomultiplier. For maceral analysis, at least 500 points on each polished block were counted under incident white light and blue light excitation. The maceral nomenclature applied was this of the Stoped- Heerien System as modified by ICCP and Sykorova.
2. For Geochemical analysis, the core sample was crushed and grinded to 200m mesh size. Total organic carbon (TOC) and sulphur content was measured by combustion of sample in Leco Carbon sulphur Analysis CS 244 after carbonate removal with 5% Hcl.
3. Extraction of bitumen or extractable organic matter (EOM) was assessed using Soxhlet Apparatus and dicholoro methane as solvent. EOM was fractioned into saturated, aromatic hydrocarbons and non-hydrocarbons by liquid column chromatography on silica gel/aluminium oxide by eluting with n-hexane and dichloromethane, respectively.
4. Rock Eval Pyrolysis is applied to identify the type and maturity of organic matter and to assess petroleum potential in sediments.
5. Pyrolysis was carried out using a closed steel vessel of 100 ml volume capacity with airtight facility. About 11.26g of grinded coal with double water amount were added in a steel vessel, air was evacuated by nitrogen flushing and tight vessel was kept in a muffle furnace at a temperature of 350-degree centigrade for 24 hours. It was removed and extracted with dichloromethane.

Formation	Age	Thickness	Lithology
Dune Sand	Recent	14-93 m	Sand, Silt & Clay
----------Unconformity----------			
Alluvial Deposits	Sub-Recent	11-209 m	Sandstone, Siltstone, Claystone, mottled
----------Unconformity----------			
Bara Formation	Middle Palaeocene to Early Eocene	0-185 m	Claystone, Shale, Coal, Sandstone, Carbonaceous Claystone
----------Unconformity----------			
Nagar Parkar Granite	Pre-Cambrian		Granite, Gabbro & Diorite

Stratigraphic sequence of Thar Coal Field of Pakistan



Location map of boreholes studied and drilled in Block No.1

RESULTS

The extractable organic matter (EOM), saturated (SHC) and Aeromatic (AHC) fractions

S.No	Sample No	Borehole	TOC %	EOM ppm	EOM g	NSO %
1	553-V	SV-13	19.38	1396.8	0.35	79.95
2	615-V	VV-14	51.83	10563.2	2.64	85.50
3	618-V	VV-14	66.71	10324.8	2.16	57.92
4	621-V	VV-14	55.32	5456.0	1.36	87.40
5	626-V	VV-14	53.33	9503.6	2.38	79.60
6	649-V	VV-14	56.42	2759.7	0.97	65.50
7	650-V	VV-12	28.12	2346.8	0.82	65.00
8	660-V	VV-12	57.34	3799.7	1.33	57.40

The Results of the Rock–Eval Pyrolysis of Thar Coal

S.No	Sample	TOC %	S %	Tmax ^{0}C	Gp mg HC/g
Bore Hole # VV-04					
1	V-643	26.13	8.93	364	28.09
2	V-644	54.59	0.8	406	126.17
3	V-645	61.04	0.87	341	56.84
Borehole # VV-14					
1	V-612	46.48	1.12	408	142.62
2	V-613	31.64	5.95	392	198.48
3	V-614	52.9	1.39	406	244.36
Bore Hole # SV-13					
1	553-V	19.86	4.01	419	75.13
2	554-V	64.4	6.71	400	185.58
3	555-V	49.21	8.63	418	184.32

IMPORTANCE

Gas is a more desirable fossil fuel because its use is considered to be better for the environment as the nation's demand increases and reserves continue to decrease. Coal bed methane fill as important niche in the domestic production portfolio. The term conventional gas includes many different types and compositions of natural gas with wide variations in its associated development and operations. CBM and other unconventional gas resources (e.g. shale gas, tight gas) are not as well defined, generally they are less productive and economically viable conventional gas.

Conventional process of extraction

Extraction of coal bed methane is not without controversy. CBM extraction involves pumping large volumes of water from coal seams in order to release water pressure that traps gas with the coal. The quality and dispersal of this water is a source of much debate. Each well is expected to produce approximately 5-20 gallons of water per minute.

A coal seam may best be visualized as a heterogeneous porous medium consisting of a bulk matrix system of homogenous low porosity, low permeability through which the gas may diffuse quite large; so parallelepiped surrounded by an orthogonal system of continuous uniform fractures of high permeability and porosity. The classical view of mass transport in the coal model has been that in the coal model has been that of a two-step process consisting of gas diffusion from the matrix into the matrix into the fractures and laminar flow of fluid through the fractures.The primary recovery leads to only 20-60% of the total recovery of methane from coal bed so to achieve maximum recovery ECBM is introduced

Enhanced Coal Bed Methane Recovery

New technologies have been proposed for extraction and recovery of CBM due to its growing importance. Enhanced coal bed methane recovery is to recover a larger fraction of gas in place. The two principle methods of ECBM recovery are 1) Use of nitrogen injection 2) Displacement desorption employing carbon dioxide injection. One important aspect of ECBM is the adsorption and desorption behaviour of gas mixtures. Primary recovery using depressurization techniques induces desorption of the CBM by lowering the overall pressure of the reservoir. On the other hand, a second gas maintains overall reservoir pressure while lowering the partial pressure of the CBM in the free gas. Injected gas also sweeps the desorbed gas through the CBM reservoir. Nitrogen is a natural choice as an injection gas because of its availability. Carbon dioxide is also promising because of benefit of greenhouse sequestration.

CONCLUSION

CBM technology is proceeding with good space to prove itself as a cleaner energy security to Pakistan as well as the World. However, production strategy of methane from CBM is very much different from conventional gas reservoir. The study revealed that the coal type, rank, volatile matter, and fixed carbon are strongly influence the adsorption capacity of methane into the coal bed. With increasing depth maturation of coal increases and generation of methane gas also increases. From the studies, it is observed that in future this field may be considered for methane extraction using advanced technology and in emergency condition. Sequestration of CO2 helps in mitigation of global warming, at the same time helps in recovery of methane gas from coal bed unveiled otherwise. However, detailed and intensive studies are required for efficient and economic production of coal bed methane.

Role of Natural gas, oil and other resources of energy is more than 99% for power generation and coal has contributed merely less than 1%. Reservoirs of conventional natural gas are depleting which are raising question for availability of energy for power generation. Compatibility of Coal can justify Underground Coal gasification technique for gasification and its utilization in Combined Cycle Station for power generation.

Technological development suggests the enhancement of non-renewable energy resources. In the current situation the energy consumption is increasing every year .the energy crises and price escalation have led to other alternative resources to compete daily increasing energy demand Coal bed Methane is an important aspect considering nation growth. CBM is a clean burning energy source which can be used as a boiler fuel and vehicle fuel. CBM is a non-conventional hydrocarbon fundamentally different in its formation processes and production technology so attention should be taken to put on development of this resource in order to meet the current crises of energy.

REFERENCES

[1] Khursheed Anwar, “Economic and Social Commission for Asia and the Pacific”, Country Paper Pakistan, Regional Seminar on Commercialization of Biomass Technology, Guangzhou, China, 2001, pp 1-4.

[2] Syed Zafar Ilyas, A Case Study to Bottle the Biogas in Cylinders as a Source of Power for Rural Industries Development In Pakistan, world Applied Science Journal, IDOSI Publications, 2006, pp127-130.

[3] Pakistan Coal Power Generation Potential, Private Power and Infrastructure Board, Ministry of Water and Power Government of Pakistan, 2004, pp 9-11.
[4] Pakistan's Thar Coal power Generation Potential, Private Power and Infrastructure Board, Ministry of Water and Power, Government of Pakistan, June 2008 pp 3.
[5] Balochistan Conservation Strategy, IUCN, Pakistan & Government of Pakistan, 2000, pp 122-138
[6] Engr. Abdul Waheed Bhutto, "Developing Coal Resources", The Dawn, Dated June 13, 2005
[7] Nazar-ul-Islam, Anwar Mohsin, Marzban Joozer and Habibullah, Mineral Statistics of Pakistan, Government of Pakistan Ministry of Petroleum and Natural Resources, Geological Survey of Pakistan, 2005, pp 2-18
[8] Engr. Abdul Waheed Bhutto, "Pakistan's coal resources" The Dawn, dated September 20, 2004
[9] Water and Power Development Authority (WAPDA) Brochure, 150 MW Lakhra Power Station Near Khanote (1993)
[10] S. Aziz, M. I. Pathan and S. A. Soomro, Erosion Problems in FBC Power Plant Based On Lakhra Coal, J. Appl. & Emerg. Sc., 2006 pp. 145
[11] S. Aziz, S. A. Soomro and M. A. Zeenat, Particle Size Analysis Of Coal & Limestone Used in FBC Power Plant at Lakhra, Mehran University Journal of Engineering & Technology, 50 (2008) 20
[12] S. Aziz, Study of technical aspects for improving the efficiency of FBC power plant at Khanot, M. E. Thesis, Chemical Engineering Department, Mehran University of Engineering & Technology, Jamshoro, (1999).
[13] Changdu and Sichvan, 3x50 MW FBC Lakhra power plant Near Khanote, Dong Fang Electric Corporation, R. of China, (1993).